TITLE:

A METHOD AND A DEVICE FOR BENDING COMPENSATION IN INTENSITY-BASED FIBRE-OPTICAL MEASURING SYSTEMS

TECHNICAL FIELD

The present invention relates to a method for measuring systems according to the preamble of the appended claim 1. The invention is especially intended for use with intensity-based fibre-optical measuring systems for pressure measurements. The invention also relates to a device for carrying out such a method, according to the preamble of the appended claim 5.

BACKGROUND ART

In connection with measuring physical parameters such as pressure and temperature, it is previously known to utilise various sensor systems by which the optical intensity of a ray of light, conveyed through an optical fibre and coming in towards a sensor element, is influenced due to changes in the respective physical parameter. Such a system may for example be used when measuring the blood pressure in the veins of the human body. Said system is based upon a transformation from pressure to a mechanical movement, which in turn is transformed into an optical intensity, conveyed by an optical fibre, which is in turn transformed into an electrical signal that is related to the measured pressure.

According to known art, such a fibre-optical measurement system may comprise a pressure sensor, an optical fibre connected to said pressure sensor, and at least one light source and at least one light detector located at the opposite end of the fibre, in order to provide the pressure sensor with light, and to detect the information-carrying light signal returning from the pressure sensor, respectively.

One problem occurring with previously known systems of the above kind relates to the fact that interference may occur in the signal transmission path,

for example caused by fibre couplings or through bending, intentionally or unintentionally, of the fibre. Already at a light deflection of the fibre, a reduction of the light signal occurs. This signal damping, caused by the bent fibre, entails that the light signal detected in the light detector, which is related to the pressure detected in the sensor element, will have a value that does not coincide with the real pressure. The size of the deviation will then depend on how much the fibre was deflected.

Through EP 0 528 657 A2 a fibre-optical measurement system for measuring pressure is known. Said system comprises a pressure sensor with a membrane, three LED:s emitting light at different wavelengths, and two photo detectors. The system is arranged so that a computing algorithm is used for correction of such temperature effects that may have been superimposed on the output pressure signal. This algorithm is based upon the relationship between membrane deflection, pressure and temperature. Correction data obtained experimentally may also be used as input data to the algorithm regarding temperature compensation.

DISCLOSURE OF INVENTION

A primary object of the present invention is to compensate, by means of a method and a device, for interference in intensity-based fibre-optical sensor systems, caused by intentional or unintentional bending of the optical fibre. This is achieved by means of a method and a device in accordance with the present invention, the characteristics of which are defined in the accompanying claims 1 and 5, respectively.

The invention is intended for bending compensation in intensity-based optical measurement systems comprising a sensor element connected to a measuring and control unit via an optical connection and adapted for providing a signal corresponding to a measurement of a physical parameter in connection with the sensor element. The invention comprises; the generation of a measuring signal that is brought to come in towards the

sensor element; the generation of a reference signal that is transmitted through the optical connection without being influenced in the sensor element, said measuring signal and said reference signal having different wavelengths; and the detection of said measuring signal and the detection of said reference signal. The invention is characterised by comprising bending compensation through correction data based upon pre-stored data concerning the relationship between the measured reference signal and the measured measuring signal as a function of the bending influence on said optical connection.

Advantageous embodiments of the invention are defined by the subsequent dependent claims.

BRIEF DESCRIPTION OF DRAWINGS

The invention will be explained in more detail below, with reference to a preferred embodiment and to the enclosed drawings, in which:

Fig. 1 shows, schematically, a pressure measuring system according to the present invention;

Fig. 1a shows an enlarged view of a sensor element intended for use in connection with the invention;

Fig. 2 shows a graph illustrating the relationship between a measured reference signal and a measured measuring signal as a function of the bending influence, in accordance with a method according to the invention; and

Fig. 3 shows, in principle, a pressure measuring system in which a so-called "smart card" can be used as the information-carrying memory unit.

PREFERRED EMBODIMENTS

Fig. 1 shows, schematically, an intensity-based fibre-optical measuring system 1 according to the present invention. According to a preferred embodiment, the arrangement is used in connection with a fibre-optical

measuring system of an as such previously known kind, which could preferably, but not exclusively, consist of a pressure measuring system. Alternatively, the invention could be used e.g. for measuring temperature and acceleration.

Two light sources belong to the system 1, comprising a first LED 2 and a second LED 3, the first LED 2 functioning to emit a first light signal of a first wavelength λ_1 and the second LED 3 functioning to emit a second light signal of a second wavelength λ_2, said wavelengths being different. The LED:s 2, 3 are connected to an optical conduit, preferably in the form of an as such previously known optical fibre 4, by means of a first link 5 and a second link 6, respectively, and also via a fibre coupling 7. The optical fibre 4 is connected to a sensor element 8, schematically illustrated in Fig. 1.

According to what is shown in detail by Fig. 1a, which is an enlarged view of the sensor element 8, said element comprises a cavity 8a, for example obtainable (according to known art) through construction by means of molecular layers (primarily silicone, alternatively silicone dioxide or a combination of the two) and an etching procedure. Preferably, a bonding procedure is also utilised in assembling the various layers of the sensor element 8. The manufacture of such a sensor element 8 is as such previously known, e.g. from the Patent Document PCT/SE93/00393. In this way, a membrane 8b is also created within the sensor element 8, the deflection of which membrane will depend on the pressure p surrounding the sensor element 8.

According to what will be described in detail below, the first light signal with the first wavelength λ_1 will come in and be reflected against the cavity 8a within the pressure sensor 8, whereas the second light signal with the second wavelength λ_2 is brought to come in onto the bottom side of the sensor element 8, i.e. towards the interface between the pressure sensor 8 and the

optical fibre 4. Hereby, the first light signal will be modulated by the pressure p acting on the membrane 8b. When the membrane 8b is influenced, the dimensions of the cavity 8a, primarily its depth d, will change, entailing a modulation of the first light signal through optical interference inside the cavity 8a.

The second light signal will be reflected against the bottom side of the sensor element 8, due to the fact that the silicone defining the sensor element 8 will only allow transmission of light with a wavelength longer than a certain limit value (e.g. 900 nm). Consequently, said first wavelength λ_1 will be selected so as to exceed this limit value. Contrary to this, said second wavelength λ_2 will be selected so as to fall below this limit value. After having determined the two wavelengths λ_1, λ_2, appropriate dimensions of the cavity 8a are determined. For example, the depth of the cavity 8a is selected to be a value of substantially the same magnitude as the two wavelengths λ_1, λ_2. The sizing of the cavity 8a is made considering the required application range for the sensor element 8 (in the current case primarily the pressure range to which the sensor element 8 is to be adapted).

The light signal (λ_1) emitted from the first LED 2 defines a measuring signal that is thus transmitted through the fibre 4 to the sensor element 8, where said light signal will be modulated in the manner described above. The second light signal (λ_2) will then define a reference signal, transmitted through the fibre 4 and being reflected by the bottom side 9 of the sensor element 8. The light signal modulated in the sensor element 8 and the light signal reflected from the bottom side 9 of the sensor element are then transmitted back through the fibre 4. The returning light signals will, through the fibre coupling 7, be conveyed into fibre links 10, 11, connected to the detectors 12 and 13, respectively. The detectors 12, 13 will detect the measuring signal and the reference signal, respectively.

The four links 5, 6, 10, 11 preferably consist of optical fibres, the fibre coupling 7 thereby preferably consisting of an as such known fibre junction device designed so as to transfer the four fibre links 5, 6, 10, 11 into the fibre 4 leading to the sensor element 8.

The system 1 also comprises a computerised measuring and control unit 14, to which the LED:s 2, 3 and the detectors 12, 13 are connected. Said unit 14 comprises means for processing the values detected by said detectors 12, 13. According to the invention, the processing of the detected values includes a compensation for intentional or unintentional bending of the fibre 4, by utilising correction data based upon pre-stored data concerning the relationship between a measured reference signal and a measured measuring signal as a function of the bending influence on the optical fibre 4. Such correction data could for example be comprised of a table or a function defining values to be used during measurements to correct the detected measuring signal.

Finally, the system 1 comprises a presentation unit 15, e.g. a display, allowing a measurement of the sensed pressure p to be visualised for a user.

Fig. 2 graphically illustrates how the above relationship between a measured reference signal and a measured measuring signal is changed during increased bending of the fibre 4. In the figure, the reference signal is referenced as "Output signal λ_2 [V]" and the measuring signal as "Output signal λ_1 [V]". Said measured relationship can be described by a function, so as to correct the measuring signal continuously with a specific value depending on the reference signal. Alternatively, the measured relationship can be used for defining a mathematical function, which in turn is used for producing corrected values during measurements with the system according to the invention. As a further alternative, a number of measurement values may be registered in a table, into which the value of the reference signal is

entered, to obtain a value (with the aid of interpolation, if necessary), with which the current measuring signal is corrected. Independently of the correction procedure used, it is performed in the above-mentioned measuring and control unit 14.

Fig. 3 shows, in principle, a pressure measuring system according to the invention, comprising an alternative measuring unit 16 to which the sensor element 8 is connected, via the optical fibre 4, in an exchangeable manner via an optical coupling (not shown in Fig. 3). Said measuring unit 16 also comprises a reader unit 17 for insertion and reading of a separate unit in the form of an information-carrying card 18 (also called "smart card"). Said card 18 comprises a memory device where data regarding the sensor element 8 are stored for use. During measurements, these data may be read by the measuring unit 16 and be used for example for bending compensation in dependence of which specific sensor element 8 that is being used for the moment. The invention thus provides a further advantage, in that different sensor elements 8 can be connected to said unit 16 without calibration, thanks to data stored on the information-carrying card 17. Said data preferably define the relationship between predetermined correction data, produced through measurements of the first as well as the second light signal at various degrees of bending of the optical fibre.

The invention is especially suitable in case a single measurement station with one measuring unit 16 is used together with several exchangeable sensor elements. In such a case, data corresponding to properties, measuring range, etc. of each sensor element, can be stored on a corresponding number of information-carrying cards, each then corresponding to (and being used together with) a specific sensor element.

As an alternative to an information-carrying unit in the form of a card, the invention can also be used with other types of separate data carriers. Further, the measuring system according to Fig. 3, as opposed to what is

shown in Figs 1 and 2, is not limited to measurements of the kind using two different wavelengths, but can also be used when measuring with for example only one wavelength.

It should be mentioned, that the card 18 may also contain other stored information than that mentioned above, e.g. information regarding the sensor type, calibration data, etc. The basic principle is, however, that the card 18 is co-ordinated with a specific sensor element such that it will comprise stored data regarding the function of the specific sensor element. Preferably, the card 18 will be provided with information - in the form of a set of parameters - allowing the properties of the sensor element 8, together with the properties of the measuring unit 16, to provide a suitable linearisation of the characteristics of the specific sensor element during measurements.

The invention is not limited to the embodiment described above, but may be varied within the scope of the appended claims. For example, the principle for data storage regarding a specific sensor on a separate information-carrying card can be used also for systems not intended for pressure measurements.